Dragi Danev, Faculty of Mechanical Engineering, Skopje, Rep. of Macedonia
Milan Kosevski, Faculty of Mechanical Engineering, Skopje, Rep. of Macedonia
Simeonov Simeon, AD RUEN Kocani, Rep. of Macedonia

IDENTIFICATION OF THE FRICTION LININGS STRUCTURE PARAMETERS WITH SIGNIFICANT INFLUENCE ON HEAVY VEHICLES FRICTION CLUTCHES WORKING CHARACTERISTICS

IDENTIFIKACIJA ONIH PARAMETARA STRUKTURE FRIKCIONIH OBLOGA KOJI IMAJU ZNACAJAN UTICAJ NA RADNE KARAKTERISTIKE FRIKCIONIH SPOJNICA ZA TESKA MOTORNA VOZILA

IZVOD: Frikcione su spojnice jos uvek dominantno u primeni kod motornih vozila. I pored cinjenice da je osnovan njihov koncept gradnje uglavnom nepromenjen, zahtevi za kvalitet i performanse su sve strozi i strozi. Za ispunjivanje tih zahteva od velikog je znacaja dalji razvoj strukture frikcionih obloga, kao i razvoj tehnologije njihove proizvodnje.
Ovaj rad prikazuje nacin na koji je oranizovano veoma opsezno istrazivanje (teorijsko i eksperimentalno) sa ciljem da se identificiraju oni parametri strukture frikcionih obloga koji imaju znacajan uticaj na njihove radne karakteristike.

KLUCNE RECI: Motorna vozila, frikcione spojnice, frikcione obloge, parametri.

ABSTRACT: Friction clutches are still dominantly used in road motor vehicles. Besides the fact that basic concept remains the same, the quality and performance requirements are stronger and stronger. Further development of the friction linings structure and production technology is crucial for fulfilling of those requirements.
This paper shows the way on which a very complex research (theoretical and experimental) was organized in order to identify the parameters of structure of friction linings having a significant influence on their working characteristics.

KEY WORDS: Motor vehicles, friction clutches, linings, parameters.

IDENTIFICATION OF THE FRICTION LININGS STRUCTURE PARAMETERS WITH SIGNIFICANT INFLUENCE ON HEAVY VEHICLES FRICTION CLUTCHES WORKING CHARACTERISTICS

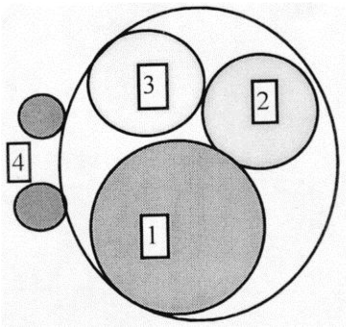
The quality of the pad is expressed by tribologic parameters, the coefficient of friction and the specific abrasion of the pad. The tribologic parameters depend upon the substances and their interrelation within the pad. The pad needs to provide for a stabile coefficient of friction and a small-scale specific abrasion, depending on the temperature, specific pressure between the friction surfaces and the velocity of friction, in order to enable the transfer of the moment of motor to the transmission and to enable the vehicle to pass a longer path.
In order to get a pad of a better quality, on the basis of the reporting in the references and the testing done in "Ruen" Kocani, the number, we have determined the factors in the structure of the pad that have an impact on the abrasive and adhesion events and the tribologic parameters of the clutch. The research aimed at determination of the quality of the thread, latex, modifiers and their inter-relation, the way of weaving of the thread and the way of knitting of the pad. It is important that the new product complies functionally and environmentally with the strict international criteria for friction pads that are recently valid.
These factors may be divided into 2 groups:

1. Factors that influence the problem of adhesion between fiction surfaces
2. Factors that have an influence on the determination of the tribologic parameters of the pads.

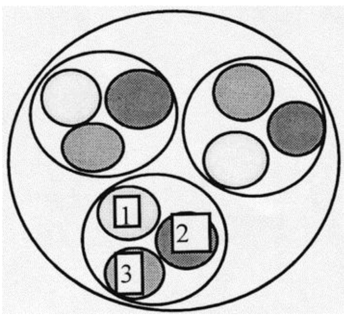
The first group of factors includes:
-type of thread
-structure of the thread
-type of impregnating material.
The second group includes:
-change in the ratio between the thread and the impregnation material
-change in the diameter of the thread
-change in the ratio of the modifiers
-composition and way of weaving of the thread
-way of knitting of the pad
Thread. The thread needs to provide resistance of the pad at high temperatures, that is, conducting of the heat from the pad to the flywheel and the clutch plate, to resist larger pressure, in order to prevent mechanical damage of the pad that would cause abrasive-adhesive events between the friction surfaces. The thread contains organic matters (cotton, viscose, acrylic, aramide etc.)and inorganic matters (glass, metal wire). The

organic components of the thread absorb the impregnating material (the more organic components, the better absorption of the organic material). Organic materials can be as filaments or weaved (they absorb more impregnating material). Capture of the impregnating material can be partially regulated by the use of calibrated holes with an impregnated thread and the number of the twists of the thread for every meter of length. The more twists per meter length, the less impregnating material is absorbed and vice versa. For fine threads (1000-2500) tex ,the number of twists is (100-250), while for thick threads, (2700-4500) tex this number is (20-80).
The metal wire included in the thread takes away the heat off the pad to the flywheel and clutch plate. Metal wire is often composed of copper or brass. The cooper has a larger heat conduction when compared to the brass, but it is softer and in case of very high temperatures and pressures it may adhere to the metallic part (this is especially true for the brakes). It oxidizes and turns to green when the protection of the surface is of law quality. The brass has a lower heat conduction, it is harder and is not so sensitive to corrosion as the copper.

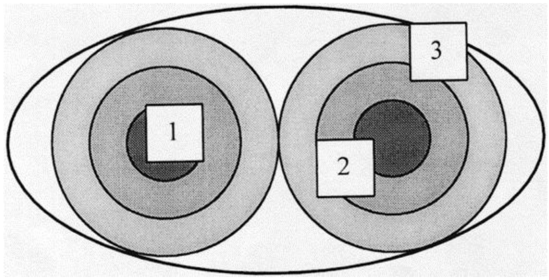
Structure of the thread. This has an impact on the abrasive and adhesive events between the friction surfaces. The thread with the same composition and a different preparation (way of weaving of the glass threads, viscose threads and the metal threads) have a different impact on the events of adhesion to the friction surfaces. The metal wires (cooper, brass) as good heat conductors (and glass and viscose threads as isolators) need to be interwoven into the thread in such a way that it would provide a better taking off the heat from the pad to the flywheel and the pressure board of the clutch. (Figure 1 shows different ways of weaving of the thread)



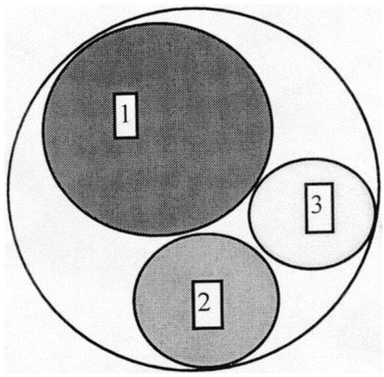
1. Glass filaments 2 Glass filaments
3. Viscose 4. Copper



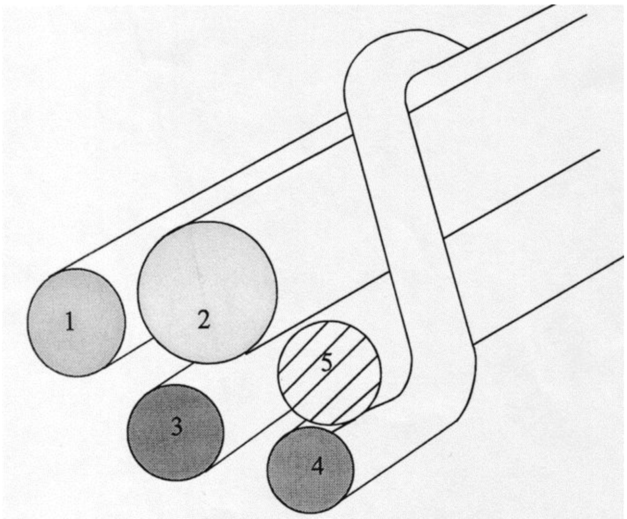
1. Glass filaments 2. Viscose filaments
3. Copper



1. Glass filaments 2. Acrylic threads
3. Glass roving



1. Metal wire 2. Glass filaments 3. Organic components



1. Rayon 2. Glass 3. Acrylic
4. Viscose 5. Copper

Fig. 1

Impregnating material. It is composed of latex, filling materials and modifiers and has an impact on the adhesion to the friction surfaces. Latex has a particular impact and it needs to be heat resistant, otherwise it would soften the impregnating material and abrasive-adhesive event would occur. The main components of the latex used for pads are butadien, acrylonitril, styren etc. Butadien is soft and provides the adhesion of the latex. Acrylonitril and the styren provide the hardness of the latex that is important for the preparation of the pads. Of the latex contain more butadien, then it is convenient for pads, but if it contains more acrylonitril then the latex is hard and does not provide for the necessary adhesion needed for the weaving of the pad. Therefore, it is important to determine the best ratio of butadien and acrylonitril (15-32)% acrylonitrid, (55-74)% butadien, up to 10% other components. In order to increase the resistance of the latex at higher temperatures, it is filled with a modifier-sulfur. Coal particles provide for a better viscosity of the impregnating material. The graphite provides for a good adhesion, and supports the coagulation of latex. Phenol resins provides stiffness of the pad. And provides equal distribution of the pressure on the whole pad. Ethalat .increases the adhesion of the impregnating material. Lucel and the polychrome increase the viscosity. Unifast softens the hard water, vulcacite increases the vulcanization.

Ratio thread/impregnating material. This ratio has an impact on the coefficient of friction and specific abrasion. The bigger percentage of the thread in the pad, contributes to a larger coefficient of friction and specific abrasion is smaller, and vice versa, less thread (and more impregnating material) leads to a smaller coefficient of friction, while the specific abrasion is larger. This ratio is (40-60)% thread and (40-60)% impregnating material.

Diameter of thread. It has an impact on the tribologic parameters of the pad in the following way. The bigger diameter of the thread provides for a better capture of the impregnating material. The diameter that would lead to the best ratio of the thread to the impregnating material needs to be determined. The increase of the diameter is proportional to the content of the organic matters, but it is not the only way of increasing the diameter. The impact of the texture composition (weight per meter length) on the tribologic parameters is as follows: thread with a smaller texture composition adsorbs more impregnating material, than thread of a larger texture composition-a relative ratio, **capture/tex**. If we have two threads of 1500 tex and one thread of 3000 tex, than both threads would absorb more impregnating material. This will mean a smaller coefficient of friction, and a larger abrasion.

Modifiers used as components are: graphite, coal particles, resins etc. Graphite is a mineral and an allotropic modification of carbon. Coal particles are amorph carbon. Phenol formaldehyde resin is a resin obtained from phenol and formaldehyde, that is, by short term heating phenol resins with an aqueous solution of formaldehyde in the presence of basic catalyzers such as ammonia or sodium hydroxide. The modifiers have an impact on the tribologic characteristics of the pad.

The percentage of graphite has an impact on the specific abrasion. When the percentage of coal particles is smaller, the abrasion is bigger and vice versa.

The percentage of coal particles has an impact on the stability of the coefficient of friction in one cycle. The smaller percentage of coal particles has a larger deviation and vice versa.

The percentage of phenol resins has an impact on the stability of the coefficient of friction depending on the number of cycles of switching on of the clutch. The smaller the percentage of phenol resins, the bigger the deviation and vice versa.

Composition and weaving of the thread. The thread is composed of (40-70)% glass, (20-40)% organic matters (cotton,, viscose etc..) and (10-20%) copper. The bigger content of glass in the composition of the thread provides for a larger coefficient of friction, and a smaller specific abrasion. More organic matters in the composition of the thread cause a bigger absorption of the impregnating material, thus the coefficient of friction is smaller and the abrasion is bigger. The presence of copper in the thread is important because of the faster taking off the heat from the pad. A bigger content of copper decreases the specific abrasion. The way of weaving of the thread has an impact on the tribologic parameters. Usually, the components of the thread are interwoven concomitantly. The second way of weaving is when viscose is interwoven around its components-glass, cotton, and copper. This type of thread can absorb more impregnating material. The third way of weaving is when non-metals elements are woven together and the metal wire is woven around them. In this way, the abrasion of the pad is decreased. Such pads are used for larger heat loads because the copper takes the heat away faster. (Fig. 1)

The way of knitting of the pads can be by spiral or a zigzag method. Dilatation of the thread in the direction of the hears is smaller, and perpendicular to the thread, they are bigger when the temperature is increased. When the weaving of the pad is spiral, in the internal diameter there is less thread, while towards the external diameter the percentage of thread is increased. When heated, due to the dilatation of the thread (in a direction perpendicular to the thread) the excess of thread from outside goes to inside and the pad is distorted. In heavy vehicles, due to the bigger power, the temperature is bigger and the deformities are bigger. Therefore, zigzag weaving is used, so that the thread crosses at angle of 90^0 in the middle of the pad, while towards the periphery the is only a small deviation of this angle. Here local pressures are annulled and there is no distortion.

The trajectory of the thread - belt during weaving by the zigzag method is a sinusoid and has the following shape (fig. 2a and fig. 2b)

$$R = [(D+d)/4] - [(D-d)/4] * \sin\omega(N * \omega)$$

D, d (mm) - external and internal diameter of the pad

N - true number of sinusoids (it is not an integer number)

ω - angle between the X-axis and the radius from the center the spot from the trajectory.

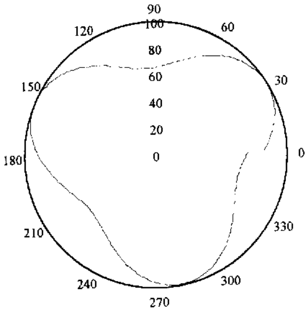
The number of circles needed for a complete filling of the space between the two diameters is:

$$T = N/K$$

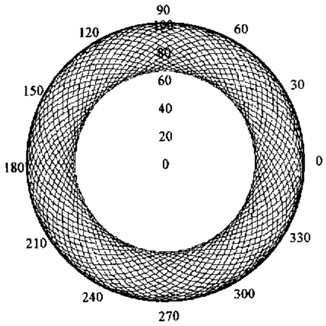
K - difference between the real and the whole integer of sinusoids

$$K = | N_0 - N |$$

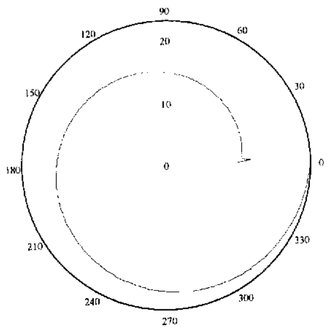
N_0 - whole integer of sinusoids



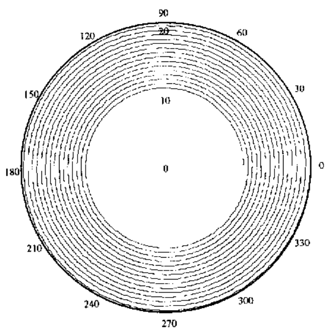
a



b



c



d

Fig. 2

Fig. c and Fig. d show a spiral way of weaving of a pad. The trajectory of the thread during the weaving of the pad is:

$$R_y = r_1 + [(r_2-r_1)/(2*\pi*i)] * \omega$$

r_1, r_2 -internal and external radius of the pad and

i -number of bends.

The way of knitting of the pads has an impact on the tribologic parameters. When spirals are used, there is a deformation of the pad, which causes an unstable coefficient of friction, and unequal and increased abrasion.

Beside the enumerated global factors that have a direct impact on the quality of the pad, the technologic process has an important impact on the:

- production of the impregnating material
- thermal processing of the pad (temperature and time)
- Impregnating material consists of latex as a basic component where other components are added (components for filling, modifiers, stabilizers etc. The mixture is prepared in homogenizers. Of particular interest is that the colloid sulfur needs to be prepared well (liquid sulfur).
- The oven where the thermal processing of the pad is done needs to provide for an adequate movement of hot air for the process of vulcanization of the pad. If the temperature in the pad is small or the time for a thermal processing is short, the process of vulcanization is not done (soft pad). There is danger that the coefficient of friction decreases (when the pad is tested part of the organic matters that form a sliding layer are burned) or friction surfaces adhere to each other. If the temperature in the oven is very high, the pad becomes unusable. The thermal processing is done by gradual increase of the temperature, 160 ^oC, 180 ^oC, 200 ^oC with (16-20) hours for heating.

The technologic procedure for production of pads that are used in worldwide known manufacturers can be divided according to the connective means:

Group "A" -connective means based on caoutchouc and resins

Group "B"- connective means based on aqueous dispersions (synthetic latex)

Worldwide, the technologic procedure from group "A" is more frequently used. In this study, the tested pads are obtained through the technologic procedure from group "B".

For heavy motor vehicles, the pads used are composed of the following components:

-threads without asbestos (heary mesh)
-synthetic latex (connective means)
-coal particles, graphite, some polidispersions (filling materials)
-sulfur, phenol resins etc. (modifiers).

Other factors that have an impact on the results of the testing are:

-temperature between friction surfaces
-specific pressure between friction surfaces
-velocity of sliding of friction surfaces

The temperature has an impact on the change of the structure of the pad and may soften the pad and facilitates its adhesion. The coefficient of friction is decreased while the specific abrasion is increased at increased temperature.

When the velocity of sliding is increased, the temperature increases and the coefficient of friction decreases, while the specific abrasion increases.

The specific pressure has a larger impact on the abrasion, and the minimal abrasion is at pressure of app. 2 dN/cm^2 .

Increasing or decreasing the pressure, enhances the abrasion of the pads.

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